
Credit: NASA

National Aeronautics and
Space Administration

Manufacturing

Compact Long-Reach Robotic Arm

Lightweight and compact arm with improved mechanical advantage and efficiency in single plane applications

NASA Langley Research Center is developing a robotic arm with lightweight joints that provide a wide range of motion. The envisioned design provides users with a long reach and numerous degrees of freedom. The arm, ideal for use in aquatic environments or for manipulation of light terrestrial loads, consists of articulating booms connected by antagonistic cable tension elements. The arm elements are structurally efficient and lightweight, and support compact packaging. The inherent mechanical advantage provided by the tendon articulation allows the use of small, efficient motor systems. The manipulator can be scaled over a large range from 10m (load-bearing arm) to over 1000m (submersible or float-supported arm). Current efforts are focusing on a 15m prototype and a 300m subsystem to test the unique robotic architecture. NASA is seeking partners to assist with the development of its concept system for specific applications.

BENEFITS

- Provides a long reach for remote inspection or manipulation in inhospitable environments.
- Uses tension stiffening for improved structural efficiency.
- Requires minimal storage space when packaged and can be easily transported.
- Design can be tailored for applications of varying reach, dexterity, or environmental requirements.
- Capability to actively change component geometry during operation (e.g. extending or relocating links and spreader arms, etc.).
- Updated drive system capable of reducing motor torques by order of magnitude compared to first generation system.

technology solution

THE TECHNOLOGY

The lightweight and hyperdextrous nature of the NASA-developed robotic arm is enabled by its tendon-articulated joints. Manipulator joints are actuated by capstans or winches located along the boom. This configuration offers significant mechanical advantage and improved efficiency over existing arms that use weighty gearboxes and motors. The arm joints have very high structural efficiency and significantly reduce manipulator mass while achieving a high level of joint stiffness. To further reduce weight while maintaining strength, stiff truss structures replace tubular links or booms between joints.

NASA has developed an algorithm to scale the arm based on tip load, reach, and tip deflection inputs for any given application. The design can be extended by the addition of articulating joints and degrees of freedom for improved arm dexterity. A prototype model of the joint is being fabricated, and range-of-motion tests are forthcoming. Required motor and controller architecture, sensors, hardware, and software systems are under development.

NASA's Compact Long-Reach Robotic Arm. Image Credit: NASA

APPLICATIONS

The technology has several potential applications:

- Earthbound:
  - Ship-to-harbor, harbor-to-ship, or ship-to-ship docking
  - Retractable covers and awnings
  - Camera booms for filming operations
  - Oil spill containment on water
  - Floating barrier deployment and maneuvering
  - Subsea cable inspection and placement
- Space:
  - Long-reach grappling, manipulation, capture, and mining of asteroids
  - Spacecraft berthing operations
  - Satellite servicing and repair operations
  - Astronaut positioning
  - In-space assembly and construction

PUBLICATIONS

Patent No: 9,168,659

Patent Pending

Doggett, William R.; Dorsey, John T.; Jones, Thomas C.; and King, Bruce D.: Development of a Tendon-Actuated Lightweight In-Space Manipulator (TALISMAN). Presented at the 42nd Aerospace Mechanisms Symposium, NASA Goddard Space Flight Center, May 14-16, 2014.

More Information

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